



FIELD APPLIED UV CURABLE FLOOR COATINGS



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Presentation Outline

- **UV CURING REVIEW**

- History and Basics of UV Curing
- UV, From Factory to Field Applied
- UV Cure Equipment
- UV Curable Raw Materials
- Processing Variables

- **CONCRETE, WOOD & VCT FLOOR COATINGS**

- Floor Selection, Preparation, Application, and Cure
- Comparison of Conventional and UV Coatings
- UV Value Proposition and Target Markets

- **SUMMARY AND CONCLUSION**

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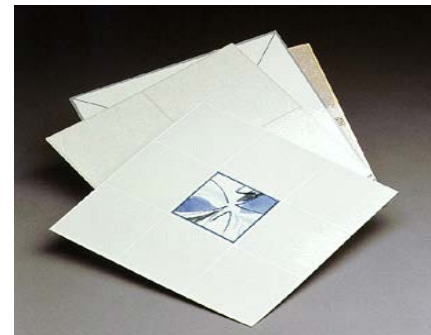
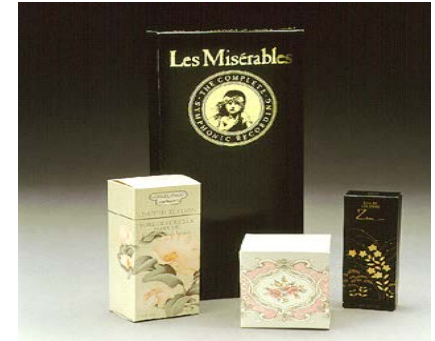
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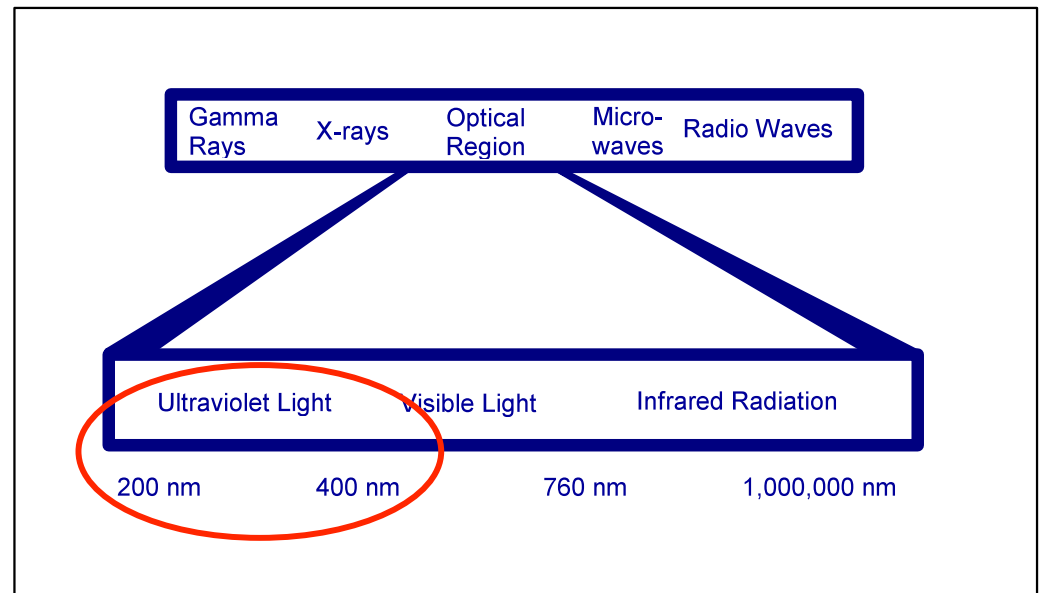
Brief History of UV Curing

- 1960's – industrial settings
 - Graphics industry; high gloss coating on cards
- 1990's – numerous industrial applications
 - Inks and coatings
 - Wood coatings
 - Metal, plastic coatings
 - Electronics
- 2000's – field applied settings
 - Floor coatings: concrete, wood, vinyl, tile
 - Automotive refinish



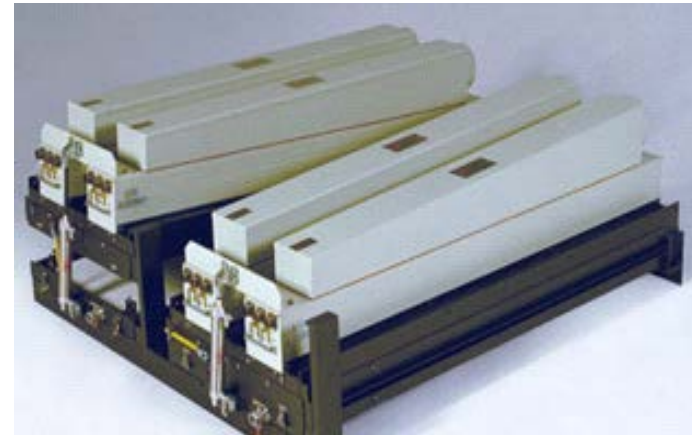
UV Curing Basics

- Radiation curing
- Energy curing
- Electromagnetic Spectrum
 - 200-400 nanometers
- UV lamps emit light
 - “dries” coating
 - (free-radical polymerization)



UV Curing Basics: Advantages

- “Drying” process
 - Very fast – fractions of a second
 - Fast return to service with fully developed properties
- Regulatory/Safety issues
 - Very low VOCs and HAPs
 - No inhalation issues
 - No flammability hazards
 - Non-hazardous materials
- Performance Properties
 - Enhanced over conventional technologies



UV Curing Basics: Disadvantages

- New process: learning curve

- Raw materials
- Formulation
- Surface preparation
- Application
- Equipment



- Limitations

- Line-of-sight cure
- Light penetration
 - Depth of cure
 - Pigmented systems



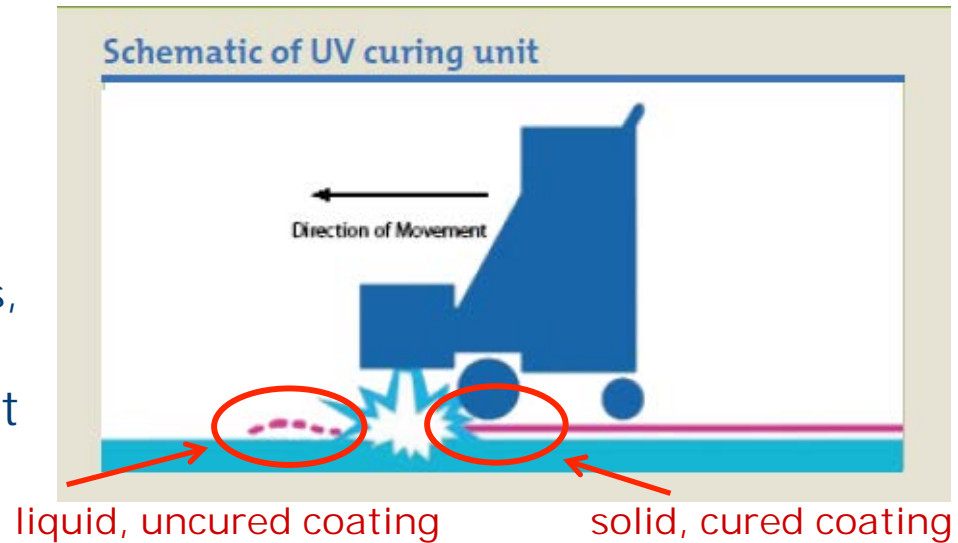
UV Curing Basics: Health & Safety

- Respiratory protection generally not required
 - Non-toxic
 - Low volatility at RT
- Eye and skin protection required
 - May be skin and eye irritants
 - Safety glasses
 - Nitrile gloves
- Protection from UV light
 - Tinted safety glasses (UVA and UVB blocking)
 - Sunscreen for exposed skin areas

UV, From Factory to Field Applied

- **DIFFERENCES**

- Substrate variations
 - Composition
 - Condition (roughness, porosity, surface contamination, hardness, etc.)
- Application method is not precise
 - Coating thickness
- Cure unit is mobile
- Cure unit moves over substrate instead of substrate moving under cure unit
- Cure conditions can vary
 - Cure distance
 - Cure speed
- Substrate is larger than UV cure unit
 - UV leakage can prematurely partially cure coating at edges of cure path
 - Overlap criteria provided by coating supplier



UV, From Factory to Field Applied

- **CHALLENGES**

- Thick coatings – PI choice
- Pigmented coatings - multiple coats
- Imperfections for gloss coatings – application/formulation expertise
- Zipper marks from light leakage – minimize leakage and shrinkage
- Gloss stripes or application marks for matte coatings – minimize shrinkage; large particle size filler; matting agent choice
- Premature cure by sunlight – limit exposure to sunlight
- Strippability versus sandability
- Balance of flexibility and hardness – formulation development
- Line-of-sight cure - dual cure
- Optimization of equipment and cure conditions – formulation development and training
- Is the coating cured? – indicator dyes

UV, From Factory to Field Applied

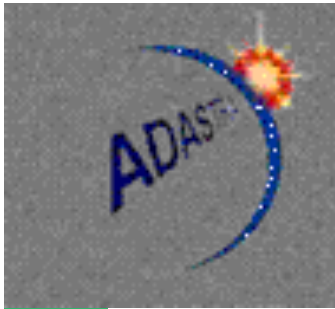
- **SAFETY**
 - Additional requirements
- **EQUIPMENT**
 - Improvements recently made

Feature	Purpose
Shutters - manual control or tied to movement of machine	Reduce accidental UV exposure if machine is lifted or moved Reduce possibility of floor damage
Instant on/off feature - tied to movement of machine	
Tip detectors	
Heat sensors	Reduce possibility of floor damage
Speed Control - self propelled or speed gauge for manual propulsion	Improve process reproducibility
RFID technology	Improve process reproducibility Tracking purposes
Laser guiding technology	Improve process reproducibility
Retractable handles	Better clearance
Light weight	Maneuverability
Emergency shut off on handle	Safety
Shielding	Decrease UV exposure of workers
Mandatory use of UV protective eye wear	
Use of clothing and creams to protect skin from stray UV light	
Cordoning off work areas	
Warning lights	

UV, From Factory to Field Applied

- EQUIPMENT

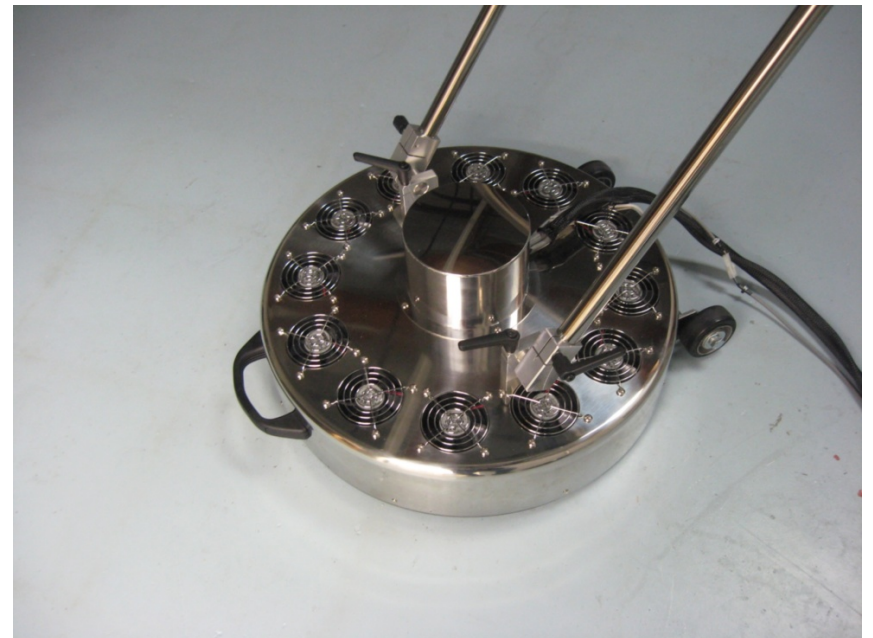
- Slides of known equipment suppliers
- Cytec attempts to show all of the equipment suppliers equally
- Additional equipment suppliers will be added as they become known to Cytec



www.uvcurenow.com



- Nova-One Hand Held System
- Circa 2000: New Spinning UV lights
- Light Weight
- 20" Omnidirectional Path
- 110 and 220 volt



CYTEC



American Ultraviolet

Since 1960. It's all we do.

www.americanultraviolet.com

- Selling Globally
- Self Propelled
- Emergency Shut off
- Durable Equipment
- Hand Held Units
- 200-240V

HANDHELD UV SYSTEMS

POWER DENSITY PER INCH
CURE WIDTH POWER SUPPLY LAMP INTENSITY

6"	1.2KW	200WPI
9"	1.2Kl	
9"	1.8Kl	
12"	1.8KV	



12" ARC LAMP

9" ARC LAMP

6" ARC LAMP
(Edge Curing)



CYTEC

WELCOME TO HID ULTRAVIOLET, Tomorrow's UV Technology... Today

HID Ultraviolet, LLC

www.hiduv.com



- Patented Instant On/Off
- RFID Technology
- Heat Sensors
- Tip Detectors
- Emergency Stop On Handle
- 110v/220v
- Conveyor system for lab work



CYTEC



Jelight Company Inc.

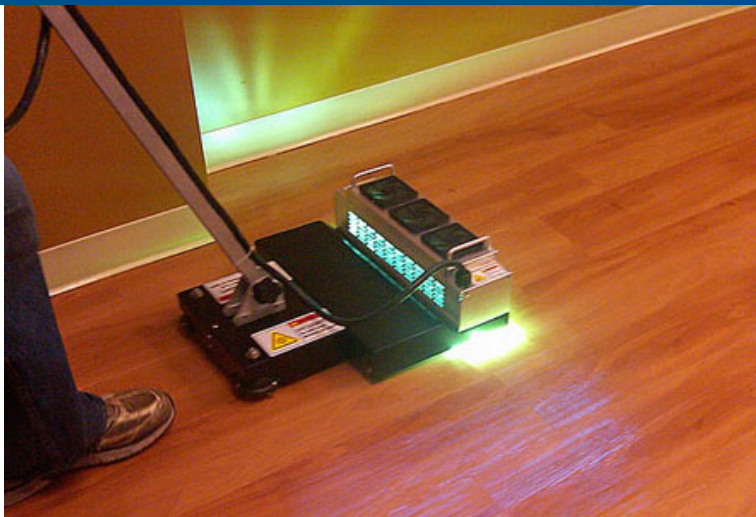
2 Mason

Irvine, CA 92618

Tel (949)380-8774 Fax (949)768-9457

www.jelight.com

- Adjustable Power Level And A Variable Lamp Focus To Accommodate Different Curing Requirements
- Exceptionally Maneuverable And Light Weight
- Ultra-low Design With Retractable Control Arm Facilitates Curing Under Obstacles With Only 14 Inches Of Clearance
- Excellent Stability, Smooth Transition Over Expansion Joints



ial location
ective



CYTEC



www.uvgreencure.com



- 3N1: floor/edge/baseboard cure
- 90 to 240 V and 50 to 60 Hz
- Constant lamp intensity
- 12" cure path
- Zero Ozone
- 35 lb
- ISO 9001 and CE Certified



About

Our

CYTEC

100% Solids UV Curable Raw Materials

- **TWO MAIN TYPES**

- **OLIGOMERS**

- Prepolymers, MW range 500-5000
 - High viscosity
 - Provide overall coating performance
 - Acrylate functionality of 2-6
 - Three main classes based on chemical backbone
 - Epoxy acrylates
 - Urethane acrylates
 - Polyester acrylates

	Epoxy Acrylate	Urethane Acrylate	Polyester Acrylate
Weatherability	+	+++++	+++
Toughness	++	+++++	+
Chemical Resistance	+++++	++	+++
Hardness	+++++	+	+++
Flexibility	+	+++++	++
Cure Speed	+++++	+	+++

100% Solids UV Curable Raw Materials

- **TWO MAIN TYPES**

- **MONOMERS**

- Reactive diluents, used to lower the viscosity of oligomers
 - Affect coating performance
 - Acrylate functionality of 1-6
 - Low MW
 - Three main classes based on functionality
 - Monofunctional
 - Difunctional
 - Tri- and higher-functional

	Monofunctional	Difunctional	Tri- and higher-functional
Viscosity Reduction	+++++	+++	+
Adhesion	+++++	+++	+
Chemical Resistance	+	+++	+++++
Hardness	+	+++	+++++
Flexibility	+++++	+++	+
Cure Speed	+	+++	+++++

Waterbased UV Resins

GENERAL PROPERTIES

- Low viscosity colloidal PU dispersion
 - < 200 cps
 - Suitable for field applied applications
- Solids of 35% to 45%
- pH $\sim 7.5 - 8.5$
- Water evaporation before UV curing is necessary
- Two classes
 - Tack free after dry, but before UV cure
 - Not tack free after dry
- Provide very good balance of coating properties

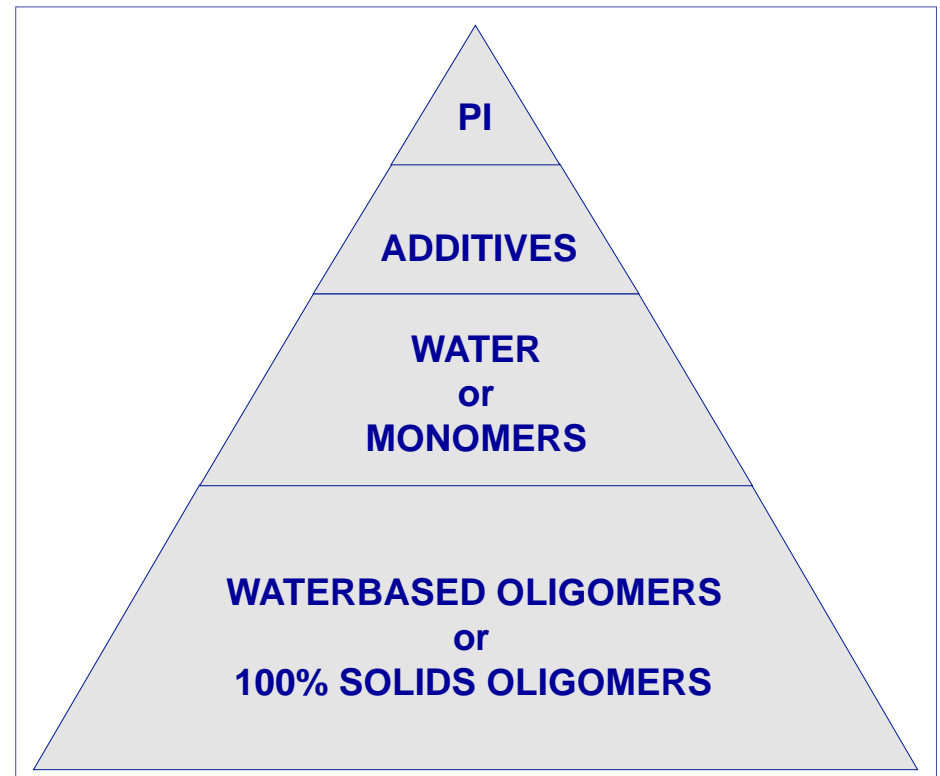


Waterbased UV and 100% Solids UV Coatings

• FIELD APPLIED COATINGS

- Low viscosity (~150 cP)
 - Application techniques
 - Air release
 - Waterbased good choice for this viscosity range
 - For 100% solids: limits choice and concentration of oligomer; monomer concentration will be high
- Coating aesthetics
 - Flow, leveling, wetting agents
 - Defoamers
 - Matting agents
- Coating thickness of 1-7 mils wet
 - Combination of PI to affect both surface and through cure

COATING BASICS – COATING PYRAMID



Waterbased UV and 100% Solids UV Coatings

100% SOLIDS UV vs WATERBASED UV

Property	100% UV	Waterbased UV
film forming resin	acrylated resin	acrylated medium MW PU
molecular weight	low	medium
crosslink density	high	medium
cure mechanism	free radical reaction	film coalescence + water evaporation + free radical reaction
diluent	acrylated monomer	water
co-solvents	no	maybe
skin irritation	maybe	no
viscosity	high	low
dry film thickness	high	low
gloss range	20-90	5-80
flexibility + hardness	difficult	easy
chemical resistance	high	high
shrinkage	high	low
adhesion	difficult	easy
tack free after dry	no	yes

Waterbased UV and 100% Solids UV Concrete Coatings

COMPARISON	WATERBASED UV	100% SOLIDS UV
GLOSS	74	90
ADHESION	4A	4A
PENCIL HARDNESS	4B	2B
SOLVENT RESISTANCE (MEK double rubs)	200+	200+
CHEMICAL RESISTANCE (24 hour spot test)		
Mustard	5	4 - Stain
Water	5	5
Formula 409	5	5
Pickle Juice	5	5
Brake Fluid	5	5
Transmission Fluid	5	5

Performance of waterbased UV is comparable to 100% solids UV

Waterbased UV Wood and 100% Solids UV Concrete Coatings

	TIME AFTER UV CURE						
	initial	1 hour	4 hours	8 hours	24 hours	48 hours	72 hours
GLOSS							
100% solids UV	90	90	90	90	90	90	90
Waterbased UV	75	75	75	75	75	75	75
ADHESION (610 tape)							
100% solids UV	4A	4A	4A	4A	4A	4A	4A
Waterbased UV	5B	5B	5B	5B	5B	5B	5B
MUSTARD RESISTANCE (60 min: 100% solids; 30 min: waterbased)							
100% solids UV	4	4	4	4	4	4	4
Waterbased UV	5	5	5	5	5	5	5
PENCIL HARDNESS							
100% solids UV	4B	4B	4B	4B	4B	4B	4B
Waterbased UV	3B	3B	3B	3B	3B	3B	3B
SOLVENT RESISTANCE (MEK double rubs)							
100% solids UV	200+	200+	200+	200+	200+	200+	200+
Waterbased UV	200+	200+	200+	200+	200+	200+	200+

UV curable coatings have fully developed properties immediately after cure

Waterbased UV Wood Floor Coatings

	SINGLE COAT	TWO COATS INDIVIDUALLY CURED	TWO COATS SIMULTANEOUSLY CURED
GLOSS	17.5	15.3	19
ADHESION	5B	5B	5B
NICKEL TEST	4-distortion	4-distortion	4-distortion
PENCIL HARDNESS	4B	HB	HB
BHMR	5	5	5
SOLVENT RESISTANCE (MEK double rubs)	200+	200+	200+
CHEMICAL RESISTANCE (24 hour spot test)			
Mustard	5	5	5
Betadine	5	5	5
RIT dye (navy, undiluted)	4-stain (5 at 30 minutes)	4-stain (5 at 30 minutes)	4-stain (5 at 30 minutes)
Xylene	5	5	5
Ethanol	5	5	5
Isopropanol	5	5	5
Water	5	5	5

UV curable coating properties are independent of the number of coatings, and the cure process

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UV Field Applied Floor Coating on Wood - Video

Concrete Floor Coatings

- **FLOOR SELECTION**

- Suitability of coating type
 - Assessed for all floors
 - Small test area(s) for coating suitability

- **FLOOR PREPARATION**

- Necessary for all types of coatings
- Two types
 - Chemical washing and cleaning
 - Mechanical etching
 - Shot blast
 - » Quick
 - » Results in extreme roughness or unevenness
 - **Diamond grinding**
 - » Eliminates roughness – very flat surface
 - » **Best for UV**

- **FLOOR SEALING**

- Necessary for porous concrete
- Can improve adhesion and appearance



Wood Floor Coatings

- **FLOOR SELECTION**

- Suitability of coating type
 - Assessed for all floors
 - Small test area(s) for coating suitability

- **FLOOR PREPARATION**

- Necessary for all types of coatings
- Two types
 - New floors
 - Stained/sealed
 - Water based stains/sealers tend to give better properties
 - Existing floors
 - Screened
 - » Adhesion
 - » Aesthetics



VCT Floor Coatings

- **FLOOR SELECTION**

- Suitability of coating type
 - Assessed for all floors
 - Small test area(s) for coating suitability

- **FLOOR PREPARATION**

- Necessary for all types of coatings
- Two types
 - New floors
 - Remove factory finish
 - Clean and dry floors
 - Existing floors
 - Remove existing finishes
 - Repair damaged areas
 - Fill holes
 - Clean and dry floors



Concrete Floor Coatings

- **COATING APPLICATION**

- Same process for conventional and UV coatings

- **PROCESS**

- Dispense coating onto area to be coated
 - Spread evenly with rubber squeegee or 1/8 inch nap, lint-free roller
 - Back roll with a larger 1/8 inch nap, lint-free roller until coating is of uniform thickness with minimal or no lapping marks



Backroll application.



Squeegee application.

Wood Floor Coatings

- **COATING APPLICATION**

- Same process for conventional and UV coatings

- **PROCESS**

- Dispense coating onto area to be coated
 - Spread evenly with T-bar or roller



VCT Floor Coatings

- **COATING APPLICATION**
 - Conventional floor polish
 - Mop & Bucket
 - UV Coating
 - Dispense coating onto area to be coated
 - Spread evenly with T-bar or roller



Concrete, Wood, and VCT Floor Coatings

- **COATING CURE**

- Different processes for conventional and UV coatings

- **CONVENTIONAL**

- Allow to cure (time for complete cure)

- **UV**

- Allow to dry (if waterborne UV), then UV cure (complete cure instantly)
 - Allow to level and de-air (if 100% solids), then UV cure (complete cure instantly)
 - Follow coating supplier's recommendations to avoid under or over cure
 - Speed
 - Overlapping criteria



Concrete Floor Coatings

COMPARISON OF COMMERCIAL FLOOR COATING CHEMISTRIES

COATING TECHNOLOGY	CURE SPEED	POT LIFE	VOC	ODOR	EASE OF CLEANING	EXTERIOR DURABILITY	ABRASION RESISTANCE	PRICE
EPOXY	Hours to Days	1-4 Hours	Low	Low	Moderate	No	Moderate	Low
URETHANE	Hours to Days	< 1 Hour	Low	Low	Moderate	Yes	Good	Moderate
POLYUREA	Minutes to Hours	< 1 Hour	Low	Low	Moderate	Some	Excellent	Moderate
POLYASPARTIC	Minutes to Hours	< 30 Minutes	Low	Low	Moderate	Yes	Excellent	High
METHYL METHACRYLATE	1 Hour	< 10 - 20 Minutes	High	High	Good	Yes	Good	High
UV CURABLE	Instant	Infinite	Low	Low	Excellent	Yes	Excellent	High

UV cured coatings bring added value based on quick return to service, infinite pot life, and excellent coating properties

Wood Floor Coatings

CONVENTIONAL vs. UV CURABLE MATTE COATINGS: SUMMARY

- Many advantages over conventional cure

Technology	1K Oil Modified PU	1K Water-borne PU	2K Water-borne PU	2K Water-borne PU-2	1K Waterbased UV PU
Cure Type	oxidative	oxidative	aziridine	isocyanate	UV
Pot Life (hours)	n/a	n/a	8-24	4-6	n/a
Dry Time between Topcoats (hours)	8-12	2-3	2-3	2-3	2-4
Time to Light Traffic (hours)	24	24	24	24	immediate after UV cure
Time to Rug Replacement (days)	14	7-14	7-14	7	immediate after UV cure
VOC (g/l)	450 - 550	220 - 350	235 - 390	240 - 350	<200
Flashpoint (°F)	110	>200	>200	>200	>200
Price (2009 data) (\$/500 sq ft coverage)	25	38	62	116	150
Adhesion	+	++	++	++	++
Nickel Test	-	---	+	+	+
BHMR	++	+	++	++	++
Hardness	-	-	-	+	++
Solvent Resistance	+	--	+	-	++
Chemical Resistance	-	--	-	-	++

VCT Floor Coatings

CONVENTIONAL vs. UV CURABLE COATINGS

PROPERTY	WATERBASED CONVENTIONAL FINISH	WATERBASED UV CURABLE COATING	100% SOLIDS UV CURABLE COATING
Application/Dry/Cure Time	+	+	++
Immediate Property Development	--	++	++
Maintenance Time	--	++	++
Lifetime/Durability	--	++	++
Aggregate Cost (Equipment and Coatings)	-	+	+
Strippability	+	+/-	+/-
Gloss	+	+	+
Adhesion	--	++	++
Hardness	+	+	+
Chemical/Stain Resistance	--	++	++

UV curable coatings have immediate property development, low maintenance and costs, high durability, improved adhesion, and better chemical and stain resistance

UV Curable Concrete Floor Coatings

VALUE PROPOSITION

- Immediate re-coatability after UV cure (100% solids UV) or after dry but before UV cure (waterbased UV)
- Fast return to service with fully developed properties
- Excellent hot tire pickup resistance
- Very fast cure
- Indefinite pot life
- Improved cleanability
- Low to zero VOCs
- Non-flammable
- Non-hazardous materials
- Excellent exterior durability
- Excellent abrasion resistance



TARGET MARKETS

- Factories/other buildings that cannot afford downtime
- Refrigerated warehouses (low temperature cure)
- Food storage warehouses (no/low VOC; low odor)
- Decorative concrete markets

UV Curable Wood Floor Coatings

VALUE PROPOSITION

- Have fast time to dry (re-coatability), and fast return to service with fully developed properties
- Are 1K systems with no pot life issues
- Have low VOCs
- Are non-flammable
- Are non-hazardous
- Use same floor preparation and coating techniques as conventional coatings
- Provide better coating properties than conventional coatings
- Minimize post-coat defects



TARGET MARKETS

- Restaurants
- Office lobbies
- Retail
- Residential
- Gymnasiums
- Refinish
- New construction

UV Curable VCT Floor Coatings

VALUE PROPOSITION

- Immediate property development after UV cure
- Quick return to service with fully developed properties
- Minimize post-coat defects
- Low maintenance requirements
- Low aggregate costs (maintenance + equipment)
- Durability
- High performance coating



TARGET MARKETS

- Retail
- Institutional
- Hospitals
- Education
- “Back Rooms”
- Refinish
- New construction

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Concrete, Wood & VCT – Summary

PROPERTY	UV CURABLE COATING		
	WOOD	CONCRETE	VCT
Pot Life	+/=	+	=
VOC	+	+	+/=
Odor	=	+/=	=
Application/Dry/UV Cure Time	=	-	++
Immediate Property Development	++	++	++
Return to Service Time	++	++	++
Ease of Cleaning	+/=	+	++
Maintenance Time/Costs	no data	+	++
Lifetime/Durability	+	+	++
Aggregate Cost (Equipment and Coatings)	-	-	+
Strippability	not applicable	not applicable	+/-
Gloss	=	=/-	=
Adhesion	=	=	++
Hardness	++	+/=	+/=
Chemical/Stain Resistance	++	+/=	++
Solvent Resistance	++	+/=	++
Hot Tire Pickup Resistance	not applicable	+	not applicable
Black Heel Mark Resistance	=	not applicable	=
Nickel Test	+/=	not applicable	++

Concrete, Wood & VCT – Conclusion

FIELD APPLIED UV CURABLE COATINGS OFFER ADVANTAGES OVER CONVENTIONAL COATINGS FOR CONCRETE, WOOD, AND VCT

- Fast return to service with fully developed properties
- Reduced VOCs
- Ease of cleaning
- Reduced maintenance time and costs
- Improved durability
- Better chemical/stain resistance
- No pot life issues
- Better hot tire pickup resistance



Contact and Website Information

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Link to literature and videos:

<http://www.cytec.com/UV/fieldapplied.php>